

37. ZOOLOGICAL RESULTS OF THE PERCY SLADEN TRUST EXPEDITION TO YUNNAN UNDER THE LEADERSHIP OF PROFESSOR J. W. GREGORY, F.R.S. (1922).

AQUATIC GASTROPOD MOLLUSCS.

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(With Plate 17).

The collection of aquatic snails made by Professor Gregory and his son in Western Yunnan is even more interesting than that of land snails, for it includes numerous specimens (both recent and subfossil) from the great lake Erh-hai, sometimes called Lake Tali, which contains one of the most interesting lacustrine faunas known. It so happens that the Indian Museum is particularly rich in specimens from this lake, for we possess not only the collection of the late Dr. John Anderson, which was described by Nevill, but also a much larger one obtained on two occasions by Dr. J. Coggin Brown of the Geological Survey of India, as well as a few shells of particular importance from the collection of the late Father Heude of Zi-Ka-Wei. Most of Benson's specimens from Cantor's Chusan collection are also in the Museum and as we have in addition shells from another great lake in Yunnan (Kunyang-hai) from the collection of Messrs. Sowerby and Fulton, I am able to give a fairly full account of what is known of the lacustrine and fluviatile gastropods of the province of Yunnan.

The following is a list of the species at present recognized, including those described in this paper. Those of which the names are marked with a star are represented in the Gregory collection. I have not been able to recognize with certainty all the Viviparidae described by Heude, but all are probably forms of the species discussed here.

LIST OF THE AQUATIC GASTROPODS OF YUNNAN.

Fam. Rissoidae.

Subfam. Lithoglyphinae.

Lithoglyphus taliensis,* sp. nov. .. Erh-hai (Subfossil?)

Subfam. Triculinae.

*Tricula gregoriana** Annd. .. Upper Mekong.

Subfam. Amnicolinae.

Hydrobioides (Parafossarulus)
delavayanus (Heude) .. Lan-kong.

Fam. Delavayidae.

Delavaya rupicola Heude .. Hai-sinear Erh-hai.

*Parapyrgula coggini** Annd. and
Prashad .. Erh-hai.

*Paraprososthenia gredleri** (Neum.) Erh-hai.

*Fenouilia bicingulata** Heude .. Lakes of Yunnan.

Fam. Melaniidae.

Semisulcospira (?) aristarchorum
(Heude) .. Upper Yangtse sys-
tem.

Semisulcospira lauta (Fulton) .. Kun-yang-hai (Yun-
nan Lake).

Semisulcospira dulcis (Fulton) .. Kun-yang-hai (Yun-
nan Lake).

Fam. Viviparidae.

*Vivipara quadrata** (Benson) .. China.

Vivipara margaryaeformis Mansuy S.E. Yunnan (fossil):
possibly Tonquin

Vivipara margaryoides Annd. .. Erh-hai (subfossil).

*Margarya melanoides** Nevill .. Erh-hai and Upper
Yangtse system.

Margarya monodi Dautz. and Fisch. S.W. Yunnan.

*Lecythoconcha lecythis** (Benson) .. S.E. Assam to Hainan
and (?) Japan.

*Lecythoconcha lecythoides** (Benson) W. Yunnan and Sze-
chuan to S E.
China.

*Lecythoconcha malleata** (Reeve) .. W. Yunnan to Japan
and S. E. China.

Fam. Limnaeidae.

*Limnaea andersoniana** Nevill .. Assam; U. Burma;
W. Yunnan; Central
Asia; N.-W. Fron-
tier of India; Nepal

Limnaea yunnanensis * Nevill . . W. Yunnan, as far
east as Erh-hai.

Fam. Planorbidae.

Gyraulus longios,* sp. nov. . . Upper Mekong.

Several points in this list are noteworthy. Firstly, we notice the complete absence of Ampullariidae, which are abundant in many parts of Burma and Siam but do not occur in any part of China, where they are apparently replaced by gigantic Viviparidae of the genus *Lecythoconcha*. Secondly, the absence of Melaniidae from Western Yunnan is peculiar. Those which occur in the eastern and central parts of the province are not related to Burmese forms. The most interesting fact, however, is the occurrence of the apparently endemic and highly peculiar lacustrine genera *Delavaya*, *Parapyrgula*, *Paraprososthenia* and *Fenouilia* in the lakes of the province. A peculiar feature of those molluscs is their close resemblance to certain tertiary forms from Central Europe.¹ A similar resemblance has been noticed between the Viviparidae of Yunnan and these of the Pleistocene beds of central and eastern Europe and the Levant. This resemblance is certainly due, as I have demonstrated elsewhere,² not to a common ancestry but to convergent evolution, and I am of the opinion that the similarity between the other lacustrine gastropods of the lakes of Yunnan and those of tertiary basins in Europe is probably due to the same cause. Before discussing the matter fully, however, it will be necessary for me to make a more detailed study of the tertiary molluscs, and this is not possible at present in Calcutta.

Family RISSOIDAE.

Subfamily LITHOGLYPHINAE.

Genus *Lithoglyphus* Hartmann.

Although this genus has been confused with the indigenous genus *Fenouilia*, at least one true species (*L. liliputanus* Gredler) has already been described from China. The radula³ has been figured by Dr. Baini Prashad and myself. I have here to describe a new species closely allied to the type-species of the genus, so far as can be seen from the shell alone.

Lithoglyphus taliensis, sp. nov.

The shell is of comparatively large size and has $3\frac{1}{2}$ whorls. The body-whorl is comparatively shallow and very oblique,

¹ See Neumayr, *N. Jahrb. f. Min. Geol. u. Pal.*, II, p. 21 (1883).

² Annandale, *Proc. Roy. Soc. (B)* XCVI, pp. 60-76 (1924).

³ *Rec. Ind. Mus.*, XVI, p. 416, Fig. 1b (1919).

expanding considerably towards the mouth, convex below and subcarinate on the periphery. The penultimate whorl is highly convex and considerably deeper than the whorl and a half above it. The apical half whorl is raised and about half as deep as the first complete whorl. The suture is linear and deeply impressed. In ventral view the body-whorl is somewhat elongate and the spire appears minute. The mouth is oblique and comparatively narrow. Its height is considerably more than half that of the whole shell. The columella is feebly arched and its callus poorly developed. The sculpture consists of fine longitudinal striae on the body-whorl, set far apart but becoming more numerous and better developed on the youngest part of the whorl. The surface is highly polished.

Height of shell	8.25 mm.
Max. diam.	7 mm.
Height of mouth	4.5 mm.

Type-specimen. M $\frac{12406}{2}$, Z.S.I. (*Ind. Mus.*).

Locality. Shang-tung near N.W. shore of Erh hai (Lake Tali), Yunnan (? subfossil) in raised beach.

The single shell has the lip incomplete. It resembles that of the European *L. naticoides* Fér. closely, but the spire is a little higher, the suture more impressed and the body-whorl not so evenly convex.

Subfamily AMNICOLINAE.

I include in this subfamily the genera separated by some authors into Amnicolinae and Bithyniinae, as they are linked together by two subgenera of *Amnicola* (*Alocinma* and *Pseudamnicola*) both of which have a spiral but calcareous operculum. The name Amnicolinae has undoubted priority.

Genus *Hydrobioides* Nevill,

Subgenus *Parafossarulus* Annandale.

1924. *Parafossarulus*, Annandale, *Journ. Malac. Soc.*, XVI, p. 28.

I have recently proposed this subgenus for the Chinese species which have the shell-sculpture (if present) spiral and lack a varix on the lip. Certain Burmese forms will also have to be included in it, the name *Hydrobioides* (s.s.) being confined to the type-species (*H. turrita*), to the various forms of *H. nassa* and to a new species which I hope to describe shortly. The shell resembles that of *Pachydrobia* Crosse and Fischer, but the operculum and the male organ are very different.

Hydrobioides (*Parafossarulus*) *delavayanus* (Heude).

1910. *Bithinia delavayana*, Heude, *Mém. Nat. Hist. Emp. Chinois*, I, p. 170, Plate XLII, Fig. 5.

I have not seen this species, which is only known from Heude's description and figures.

Subfamily TRICULINAE

1924. Triculinae, Annandale, *American Journ Hygiene*, Monographic Ser. III, p. 276.

I have recently proposed this new subfamily for the genera *Tricula* Benson, *Taihua* Annand. and *Oncomelania* Gredler.

Genus *Tricula* Benson.

T. gregoriana is figured in the paper cited Plate XXXVI, Figs. 1, 2.

Tricula gregoriana Annandale.

Shell small, solid, slender, elongate, ovate, conoidal, acuminate, naturally pale fulvous but covered with a blackish deposit, with strong longitudinal striae, with $6\frac{1}{2}$ whorls; the suture impressed, not very oblique, with the upper margin of the whorls narrowly flattened outside it: the body-whorl in dorsal view about as deep as the two preceding whorls together; the umbilicus imperforate; the mouth ovate, oblique, sharply pointed and slightly retroverted above; the peristome thin, continuous.

Operculum horny, thin, paucispiral, ovate.

Type-specimen. M $\frac{12368}{2}$, Z.S.I. (Paratypes sent to the British Museum.)

Locality. Cliff above the Mekong at the Awa bend, Yunnan; altitude 6,400 feet.

Family DELAVAYIDAE, nov.

I propose this new family for the peculiar Chinese molluscs of the genera *Delavaya* and *Fenouilia* Heude, *Parapyrgula* Annandale and Prashad and *Paraprososthenia* Annandale. All these genera are apparently endemic in Yunnan as living forms, but *Paraprososthenia* is also known as a tertiary fossil from the Northern Shan States of Burma.

The family may be defined as follows:

Small pectinibranchiate gastropods of lacustrine habitat with thin but porcellaneous shells of turritid or trochiform (or neritiform) shape and covered with a thin adherent, but coriaceous periostracum of a pale olivaceous colour. Operculum thin, paucispiral, ovate. Radula with the dental formula 2.1.1.1.2; the central tooth unicuspid without lateral denticulations but with a series of basal denticulations at either side; the laterals with a single very broad and prominent cusp, with or without small subsidiary denticulations; the marginals with a homogeneous series of sharp

denticulations. Gill-filaments long, extending almost all the way across the roof of the branchial chamber. Male intromittent organ absent (? always).

Type-genus. *Delavaya* Heude.

Geographical and palaeontological range. The lakes of Yunnan and possibly Cambodia; also the tertiary lake-beds of the Northern Shan States of Burma.

Key to the Genera of Delavayidae.

1. Shell trochiform *Fenouilia*.
2. Shell turritid, conical or conoidal.
 - A. Shell smooth, conoidal. Lateral teeth of radula without subsidiary denticulations .. *Delavaya*.
 - B. Shell with a spiral ridge or ridges.
 - I. Shell with a single smooth peripheral ridge. Lateral teeth of radula with lateral denticulations .. *Parapyrgula*.
 - II. Shell with more than one tuberculate spiral ridge .. *Paraprososthenia*.

Possibly the Cambodian genus *Lacunopsis* Deshayes also belongs to this family. The shell is neritiform with the spire lateral in position and with a tooth on the columella. The radula (figured by Poirier in *Journ. Conchyliol.*, XXIX, p. 6, Plate III, Fig. 5, 1881) has a unicuspid central and an enlarged cusp on the laterals with subsidiary denticulations.

I have examined good series of the shells of all the Yunnanese genera and the radula of all but *Paraprososthenia*; also the soft parts of *Fenouilia* and dried specimens of *Delavaya* and *Parapyrgula*.

The texture of the shell and periostracum and the structure of the radular teeth are particularly characteristic, as is also, in all probability, the absence of an intromittent organ in the male. In this last character, and also to some extent in the structure of the radular teeth, the family approaches the North American Pleuroceratidae, in which Dr. Baini Prashad and I included three of the genera provisionally in 1919.

Genus *Delavaya* Heude.

1889. *Delavaya*, Heude, *Journ. Conchyliol.*, XXXVIII, p. 46.

Delavaya rupicola Heude.

1890 *Delavaya rupicola*, Heude, *Mém. Hist. Nat. Emp. Chinois*, I, p. 172, Plate XXXIII, Figs. 8-9, 10 and 10a.

1919. *Delavaya rupicola*, Annandale and Prashad, *Rec. Ind. Mus.*, XVI, p. 423.

This species, which was described from the lake Hai-si near Erh-hai in Yunnan, is not represented in the Gregory collection, but I have examined a series of shells from that of Heude. From one of these my assistant Mr. Srinivasa Rao has extracted the radula. It agrees fairly well with Heude's figure, except that three basal denticulations are present on each side of the central tooth, whereas he showed a simple ridge in this position. The laterals differ from those of *Parapyrgula* in having no subsidiary denticulations at the sides of the cusp.

Heude published figures of the branchial lamellae and of the head. He shows the latter as bearing on the neck behind the eyes an intromittent organ apparently like that of certain "Hydrobiidae," but as his figures were drawn from dried specimens no great reliance can be placed upon them. It seems to me not improbable that the so-called penis was really a fold of the mantle.

The species (and the genus) is known only from a small lake in the neighbourhood of Tali-fu.

Genus *Parapyrgula* Annandale and Prashad.

1919. *Parapyrgula* (subgenus of *Paraprososthenia*), Annandale and Prashad, *Rec. Ind. Mus.*, XVI, pp. 416, 420, Figs. 1D, 2.

The radula of the monotype of this genus differs in so important a character (the presence of subsidiary denticulations on the cusp of the lateral teeth) from that of *Delavaya* that they must be regarded as distinct. The structure of the suture of the shell is also very different and its perfectly conical outline with a single smooth spiral ridge is characteristic.

The shell differs from that of *Pyrgula* (including Neumayr's subgenus *Diana*) in its much more expanded mouth and particularly in the structure of the periostracum, which in *Pyrgula* is quite smooth. Nothing seems to be known of the anatomy of that genus, but the radula in the apparently allied *Pyrgulopsis* of North America has many fine denticulations on all the teeth.¹

Parapyrgula coggini Annandale and Prashad.

A large series of empty shells, with equally large or even larger series of those of *Fenouilia bicingulata* and *Paraprososthenia gredleri*, was obtained from the earth of a raised beach at Shang-kuan near the N.W. shore of Erh-hai. Dr. Coggin Brown collected living specimens on the lower surface

¹ See Walker, *Univ. Michigan Mus. Publ.* No. 6, p. 30, Fig. 102 (1918).

of stones in the lake at the same place. The specimens show little variation.

Both this and the next genus are known only from Erh-hai, at any rate living.

Type-specimen. M $\frac{11598}{2}$, Z.S I. (*Ind. Mus.*).

Genus *Paraprososthenia* Annandale.

1898. *Prososthenia*, Neumayr (*nec* 1869), *Wiss. Ergebn. Reise Béla Széchenyi*, II, p. 653.
 1919. *Paraprososthenia*, Annandale, *Rec. Geol. Surv. Ind.*, L, p. 209.
 1919. *Paraprososthenia*, Annandale and Prashad, *Rec. Ind. Mus.*, XVI, p. 42).

Unfortunately we still lack information about the operculum, radula and soft parts of the genus, but the structure of the periostracum, the texture of the shell and the character of the lip, which is thin and somewhat expanded, are so like those of *Parapyrgula* that a close relationship is indicated.

The shell differs from that of the Kainozoic European *Fossarulus* in its thin outer lip and somewhat expanded mouth.

Paraprososthenia gredleri (Neumayr).

1883. *Diana gredleri*, Neumayr, *N. Jahrb. f. Min. Geol. u. Pal.*, II, p. 24.
 1898. *Prososthenia* (?) *gredleri*, *id.*, *op. cit.*, p. 654, Plate IV, Figs. 2, 3.

Professor Gregory's expedition obtained many specimens, as already stated, from earth near the N.W. shore of Erh-hai and I have found in the collection of the Zoological Survey of India a number of fresher shells from the same place collected by Dr. Coggin Brown. Among these there are some very young shells in which the protoconch is fairly well preserved. It differs considerably from that of the Burmese fossil *P. minuta*, in which the spiral sculpture is tuberculate from its commencement, whereas in *P. gredleri* it has the character of a smooth and prominent ridge on the 2nd, 3rd and 4th whorls. The extreme apex is missing in all the specimens.

The periostracum is of a pale green colour, thin but thrown into characteristic vertical folds, especially over the prominent parts of the sculpture.

Genus *Fenouilia* Heude.

1889. *Lithoglyphus*, Neumayr (*nec* Hartmann), *op. cit.*, p. 655.
 1889. *Fenouilia*, Heude, *op. cit.*, p. 46.
 1919. *Fenouilia*, Annandale and Prashad, *op. cit.*, p. 417.

Fenouilia bicingulata Heude.

1889. *Fenouilia bicingulata*, Heude, *op. cit.*, p. 46.
 1890. *Fenouilia bicingulata*, *id.*, *op. cit.*, p. 172, Plate XXXIII, Fig. 11.

1898. *Lithoglyphus Kreitneri*, Neumayr, *op. cit.*, p. 655, Plate IV, Figs. 7, 8.
1904. *Julienia carinata*, Fulton, *Journ. Malacol. Soc.*, XI, p. 521, Plate IV.
1919. *Fenouilia kreitneri*, Annandale and Prashad, *loc. cit.*, Fig. 1C (radula).

This appears to be the most widely distributed species in the family. It has been described under three different names from three of the lakes of Yunnan, from Erh-hai, from Hai-si in the same district and from Kun-yang-hai near Yunnan-fu. I have nothing to add to what was said by Dr. Baini Prashad and myself in 1919.

From *Julienia* it differs in the structure of the animal and the radula as well as of the shell.

Family MELANIIDAE (Tiaridae).

This family, as I have already pointed out, is poorly represented in the fauna of Yunnan and the only specimen in the Expedition's collection is a distorted shell of *Melanoides* from Bhamo in Burma. The three species recorded from the province all seem to belong to the genus *Semisulcospira* (Boettger),¹ but I have not seen Heude's *Melania aristarchorum*.² I have, however, examined shells of *M. dulcis* and *M. lauta* Fulton³ from Kun-yang-hai, both of which certainly belong to the genus. The operculum of the former is somewhat peculiar; it is so broadly ovate as to be almost subcircular, but the structure is that characteristic of *Semisulcospira* and *Melanoides* resembling that of *S. libertina* (Gould), the type-species of *Semisulcospira*, much more closely than it does that of *M. tuberculatus* (Müller), the type-species of the other genus.

Family VIVIPARIDAE.

Genus *Vivipara* (auct.).

The majority of the Chinese species of *Vivipara* belong to a peculiar group which we may call *Viviparae Angulares*. The shell is elongate and more or less conical, rimate and somewhat flattened at the base, acuminate, usually rather thick. Solid, smooth or almost smooth spiral ridges are frequently present upon it and at least traces of them can always be distinguished. The colour is olivaceous, often with black vertical streaks; dark spiral bands are absent. The radula and operculum agree with those of *V. vivipara* and Mr. Srinivasa Rao, who has dissected several Chinese forms, finds no constant anatomical peculiarities, except that the number of advanced embryos in the uterus is small.

¹ Boettger, *Jahrb. Malak. Ges.*, XIII, p. 4 (1886). See also Annandale, *Journ. Malac. Soc.* XVI, pp. 30-33 (1924).

² Heude, *op. cit.*, p. 165, Plate XLI, Fig. 26 (1890).

³ Fulton, *Journ. Malac. Soc.*, XI, pp. 51, 52, Plate IV, Figs. 2, 4 (1904).

Vivipara quadrata (Benson).

(Plate 17, Fig. 2).

1842. *Paludina quadrata*, Benson (under Cantor), *Ann. Mag. Nat. Hist.*, IX, p. 487.1877. *Paludina angularis* (in part), Nevill, *Cat. Moll. Ind. Mus.*, E., p. 31.

This appears to be the common *Vivipara* of China. It has many forms, which in large series can often hardly be distinguished, and seems to be in much the same evolutionary state as *V. bengalensis*. Many authors have confused it with *V. angularis* (Müller),¹ but it differs in the consistency of the shell, which is always much more porcellaneous, in its less conical form, in its thinner and sharper columellar fold and especially in the sculpture of the shell, which always shows traces of spiral ridges but has never the three sharp, clean-cut ridges on each whorl (above the periphery of the body-whorl) referred to by Müller in his original description. The two species both occur at Canton, from the rivers approaching which *V. angularis* was originally described. Photographs 1, 2 on Plate 17 illustrate these differences clearly.

The typical form of *quadrata* (Plate 17, Fig. 2) from S.E. China is very elongate and often almost subcylindrical. It varies, however, both in shape and size; its distinctive character is the vertical flattening of the whorls to which Benson referred in his specific name. This feature is much less marked in other forms of the species. I do not understand Benson's statement that the eyes are on pedicels while in other *Viviparae* they are sessile. I can, indeed, see no difference in this respect in the forms of which I have examined the animal, except that the pedicels are perhaps a little narrower in the Chinese than in the Indian and European forms.

In the collections from Yunnan which I have examined there are no specimens of the typical form of the species, but three forms are present which are sufficiently distinct to be given names, although intermediate individuals occur both between them and approaching the *forma typica*. These I call *minor* (Nevill), *dispiralis* (Heude) and *limnophila* (Mabille). My *V. margaryoides* seems to be specifically distinct although allied to the form *dispiralis*. The reticulate shell sculpture is particularly characteristic.

Form minor (Nevill).

(Plate 17, Fig. 5).

1885. *Paludina aeruginosa* var. *minor*, Nevill, *Hand List Moll. Ind. Mus.*, II, p. 23.

¹ *Nerita angularis*, Müller, *Hist. Verm.*, p. 187 (1774). See also Walker, *Nautilus*, XXXII, p. 114, Plate VIII, Figs 4, 5 (1919).

This is a small, conoidal, comparatively thin-shelled form with the spiral ridges indefinite and variable, but never prominent and the mouth of the shell relatively large. The shell when fresh is of a bright olive-green colour, sometimes with a greyish tinge and with occasional black vertical streaks.

The type specimens (No. 2321, *Ind. Mus.*) are from Kulang-su in Amoy, but the form seems to be common in the mountains of western Yunnan. It was collected by the Percy Sladen Trust Expedition at several places on the upper Mekong and the upper Salween between the Burmese frontier and Tali-fu at altitudes between 6,000 and 7,000 feet, and occurs both in rice-fields and in streams, the latter probably sluggish.

Form *limnophila* Mabilie.

(Plate 17, Fig. 4).

1886. *Vivipara limnophila* and *V. seerenda*, Mabilie, *Bull. Soc. Mal. France*, III, pp. 72, 74, Plate II, Figs. 4, 5.

This form is distinguished from the form *minor* chiefly by its larger size and much thicker shell. The size of the mouth is variable. The series before me from Erh-hai offers a complete transition between Mabilie's two supposed species, but his figure of *limnophila* is of an exceptionally large shell and I have seen none so big. The shells in our collection are all from raised beaches.

The form is apparently endemic in Erh-hai but I know nothing of its ecology; some specimens of *dispiralis* from a swampy lake north of Ho-chang approach it closely.

Form *dispiralis* (Heude).

(Plate 17, Fig. 3).

1890. *Paludina dispiralis*, Heude, *Mém. Nat. Hist. Emp. Chinois*, I, p. 175, Plate XXIX, Fig. 12.

This is a large, elongate, acuminate, more or less conoidal form with a thick shell. Both the outline of the spire and the prominence of the sculpture vary considerably, but the latter is never very definite and it is almost always possible to see round the periphery in a good light a double spiral ridge, which doubtless suggested the name. The shell is less cylindrical than that of *quadrata* (*s.s.*) and has the whorls more convex. Intermediate specimens between *dispiralis* and *limnophila* are common.

Heude says that this form occurs in the waters of southern Yunnan. Numerous specimens were obtained by Dr. Coggin Brown and also by the Gregory expedition in a raised beach at Shang-kuan on the N.W. shore of Erh-hai (some of these have the periostracum still present in places) and also (fresh) from the swampy lake north of Ho-ching on the

Yangtse system (7,800 feet). The form is thus evidently of wide distribution in the province.

***Vivipara margaryoides* Annandale.**

(Plate 17, Figs. 6, 7).

1924. *Vivipara margaryoides*, Annandale, *Proc. Roy. Soc. London*, (B) XCVI, p. 64, Fig. 4A.

The shell is thick, of large size, much higher than broad and of turritid form, the body-whorl being relatively broad, the spire much narrower but approximately of the same height. The body-whorl is much broader than high in dorsal view, somewhat oblique and distinctly convex. In ventral view the upper part is convex but below the umbilicus, which is closed or minutely rimate, it recedes considerably. There is no peripheral keel or angle. The aperture is somewhat flame-shaped, pointed and retroverted above, broadly rounded below, and oblique in both planes. It is not much higher than broad. The columella is arched and very oblique, with its callus narrow but stout and expanding a little below. The peristome is complete. The outer lip is thick, but not more so than the rest of the shell. The spire has an elongate, distinctly conoidal form, and consists of $5\frac{1}{2}$ to $6\frac{1}{2}$ whorls. The apex is minutely flattened. The lowest three whorls are distinctly convex. The suture is narrowly impressed and not very oblique, always more or less irregular towards the apex. The surface of the shell is highly polished and there are no spiral ridges or rows of tubercles,¹ but at any rate on the body-whorl close set, outwardly curved, somewhat irregular, coarse longitudinal striae or fine costae are visible to the naked eye. These are also present but finer on the rest of the shell and are crossed on the spire by numerous fine impressed spiral lines, which give the surface a minutely reticulate appearance.

Measurements of Shells.

	1 (type)	2	3	4	5	6	7
Height ..	47.5	imperfect	44.75	44	43	42	41.5
Max. diameter ..	29.5	32	28.5	27.5	26	26	27.25
Height of mouth ..	19.25	22	19.5	19.5	20	18	17.5
Max. diameter ..	14.75	16	13	13.5	14.5	13	12.5

¹ In young specimens faint traces of spiral ridges can sometimes be detected.

Type-specimen. M $\frac{1\frac{2}{2}10}{2}$ Z.S.I. (*Ind. Mus.*).

Locality. Lake Tali (Erh-hai), Yunnan. Apparently sub-fossil.

This species seems to be very closely allied to *V. margar-yaeformis* Mansuy,¹ found fossil in the dry lake-basin of Mong-tsu in Yunnan, but has the body whorl relatively broader and the spire more distinct. Except for the smooth and polished surface of the shell it would undoubtedly be regarded as a *Margarya*.

Genus *Margarya* Nevill.

1877. *Margarya*, Nevill, *Journ. Asiat. Soc. Bengal*, XLVI (2), p. 30.

1909. *Margarya*, Kobelt, *Paludina*, (*n.f.*), *Conch. Cab.*, p. 187, Plates XXXVII, XXXVIII.

Margarya melanoides Nevill.

1905. *Margarya melanoides* with varr. *Delavayi*, *carinata*, *Francheti* and *tropidophora*, Dautzenberg and Fischer, *Journ. Conchyliol.*, LIII, pp. 421-425.

1918. *Margarya melanoides* (in part), Mansuy, *Bull. Serv. Geol. Indochine*, III, fasc. 3, p. 2, Plate II, Figs. 4-6, 9.

Professor Gregory obtained specimens both at Erh-hai and from a swampy lake north of Ho-ching on the Yangtse drainage (7,500 feet). Dautzenberg and Fischer record its occurrence with the succeeding species, but I am doubtful as to the identity of their specimens.

Type-specimen. 2286, *Ind. Mus.*

Margarya monodi Dautz. and Fischer.

1905. *Margarya melanoides* varr. *Monodi*, *Mansuyi*, *obsoleta*, Dautzenberg and Fischer, *op. cit.*, pp. 423, 524, figs. 1-5.

1918. *Margarya melanoides* (in part), Mansuy *op. cit.*, p. 2, Plate I, Figs. 9-11, Plate II, Figs. 7, 8.

These forms seem to me to be specifically distinct from *M. melanoides*. The shell is ornamented with regular, smooth, spiral ridges, which may be obsolete; the body-whorl is relatively narrow and the spire much exserted and more or less cylindrical.

The species occurs, living and fossil, in S.W. Yunnan.

Genus *Lecythoconcha* Annandale.

1920. *Lecythoconcha*, Annandale, *Rec. Ind. Mus.*, XIX, p. 114.

The genus is distinguished from *Vivipara* mainly by the structure of the mantle. The shells are large, thin, globose or

¹ Mansuy, *Bull. Serv. Geol. Indochine*, III, fasc. III, p. 3, Plate I, Figs. 1-7; Plate II, Figs. 1-3 (1918). This form is possibly identical with *V. ratei* Crosse and Fischer f. *elongata*, Dautzenberg and Fischer, *Journ. Conchyliol.*, LIII, p. 420, Plate X, Fig. 18 (1905).

conical, of a greenish colour (which turns brown or black on exposure) and normally without dark spiral bands. The operculum has a well-defined pit on the external surface corresponding to a boss or tubercle on the internal surface and the muscular scar is poorly developed. The radula has no very characteristic features, but the inner lateral denticulations of the lateral teeth exhibit a curious but inconsistent tendency to become bifid. I have seen this in Chinese and Japanese species as well as in the type-species from Manipur.

Three distinct but closely allied species are found in Yunnan and occur in the Gregory collection. They may be distinguished as follows:—

- I. Shell ovate, at least 1·7 times as high as broad, with the upper surface of the whorls convex and the mouth ovate and projecting little beyond the outline of the upper part of the body-whorl . . . *L. lecythoides*.
- II. Shell more globose, not more than 1·4 times as high as broad, with the upper surface of the whorls distinctly flattened and the mouth projecting considerably beyond the outline of the upper part of the body-whorl.
 - A. Shell decorated with numerous fine, distinct spiral linear ridges *L. malleata*.
 - B. Shell without such ridges . . . *L. lecythis*.

As these forms remain distinct over a very broad area, while exhibiting a wide range of variation in themselves, it seems better to regard them as species rather than varieties, as some conchologists have done. There seems to be very little anatomical differentiation in the genus.

In Yunnan and in China generally, as I have already pointed out, the species of this genus completely replace the "apple-snails" or Ampullariidae, which are the largest fresh-water Gastropods in Peninsular India east of the Punjab and also in Burma. In the valley of Manipur, in which *L. lecythis* is one of the dominant forms, the Ampullariidae are scarce and have only been found in the immediate neighbourhood of Imphal, where they may have been introduced. They also appear to be scarce in the eastern parts of Upper Burma. The Ampullariidae have a profoundly modified respiratory apparatus which fits them for long periods of aestivation and hibernation out of water and permits them to breathe air when living amidst congested vegetation in shallow water. *Lecythoconcha*, the shells of some species of which closely resemble those of *Pachylabra* (the Ampullariid genus in which most of the Indian Ampullariidae are included), exhibit no such modification, but the muscular structure of the edge of the mantle enables the orifice of the branchial cavity to be closed tightly. This may be useful not only in excluding

parasitic leeches, as it undoubtedly does, but also in retaining water in the cavity when the animal is aestivating or hibernating. Certain forms of *L. lecythis* are known to bury themselves in the mud in dry weather and to be capable of prolonged existence in a torpid state.

***Lecythoconcha lecythis* (Benson).**

1921. *Lecythoconcha lecythis*, Annandale, *Rec. Ind. Mus.*, XXII, pp. 247 (Fig. 11), 545, 552, 553, 554, Figs. 3C, 6A, 7A, Plates V, VI, Figs. 1, 2.

The protoconch of this species is very characteristic (*op. cit.*, p. 247, fig. 11). Its apex is depressed and concave and the first complete whorl at first projects upwards and then descends.

The specimens collected by the Sladen Trust Expedition all belong to the small rice-field phase (*ampulliformis* Eydoux) and there are many specimens of the same phase from western Yunnan in the Indian Museum. We have also a perfectly typical shell of the large marginal phase from Erh-hai (J. Coggin Brown coll.). This probably marks the eastern limit of the range of the larger phases of the species, the smaller phase of which extends from the upper waters of both the Chindwin and the Irrawadi to Hainan and possibly Japan.

Type-specimens. 2300, *Ind Mus.*

Form *crassior*, *nom. nov.*

1909. *Vivipara* [*chinensis* (?) var.] *compacta*, Kobelt, *Paludina, Conch. Cab. (n.f.)*, p. 113 (in part), Plate XVIII, Fig. 8, *nec Nevill Hand List Moll. Ind. Mus.*, II, p. 20 (1885).
1890. *Paludina lecythoides*, Heude (*nec Benson*), *Mém. Hist. Nat. Emp. Chinois*, I, p. 174, Plate XXIX, Fig. 6.

Several specimens from a pool in a rice-field at Yangchang (Salween system), altitude 5,500 feet and some from Howan on a tributary of the Mekong (west bank), altitude 5,300 feet. Also known from Bhamo in Burma. The form, therefore, occurs on the upper waters of the three western rivers of Yunnan.

There has been confusion between this form and Nevill's *Paludina chinensis*, var. *compacta*. The latter is a form of *Vivipara quadrata* and was described from Formosa, whereas Nevill rightly identified specimens from Bhamo and Yunnan as *L. lecythis*. Unfortunately, however, shells of both the *Vivipara* and the *Lecythoconcha*, were sent to Kobelt, who called those from Bhamo *compacta* and those from Formosa *formosensis*, regarding both as probably mere varieties of "*Vivipara*" *chinensis*. He went further, indeed, for the type-species of his *formosensis* actually belongs to the type-series of Nevill's much earlier *compacta*. Kobelt's figure of *compacta*, from a shell from Hainan, is accurate for my new form, whereas

his figures of *formosensis* (*op. cit.*, Plate LXXVII, Figs. 6, 7) represent Nevill's *compacta*. I have both series of specimens before me. The specimens from Formosa have the operculum of a *Vivipara* and those from Bhamo that of a *Lecythoconcha*.

Type-specimen. M $\frac{12425}{2}$, Z.S.I. (*Ind. Mus.*).

L. lecythoconcha f. *crassior* differs from all phases of the *forma typica* of the species in its thicker shell and less projecting mouth. It is probably the form figured erroneously by Heude as *P. lecythoides* Benson. If so, its range extends from Chusan and Hainan to Western Yunnan and Bhamo in Upper Burma.

Lecythoconcha lecythoides (Benson).

(Plate 17, Fig. 8.)

1842. *Paludina lecythoides*, Benson, *Ann. Mag. Nat. Hist.*, IX, p. 488.
 1855. *Paludina lecythoides*, Benson, *Journ. Asiat. Soc., Bengal*, XXIV (2), p. 130.
 1890. *Paludina fluminalis, longispira, ventricosa*, Heude, *op. cit.*, pp. 174, 175, Plate XXXIX, Figs. 3-4, 5.

This species is not identical with the *Paludina chinensis*, originally figured in Griffith's *Animal Kingdom* (Vol. XII, Plate I, Fig. 5: 1834), but differs considerably in outline, in colour, in the shape and inclination of the mouth and probably in the structure of the protoconch which, however, is not shown in the figure cited. This figure, on the other hand, agrees very closely with that published by Heude of his *P. diminuta* (*op. cit.*, Plate XXXIX, Fig. 9) and appears to represent a form closely allied to the same authors *P. catayensis*.

There are three specimens in the Indian Museum from Cantor's collection labelled "*Paludina lecythoides*, Chusan Type" by Benson. One is large but broken and abnormal both in colouration (in its irregular dark spiral bands) and in the form of the whorls. The other two are considerably smaller and of a bright olivaceous green shade with longitudinal dark streaks. One, which I select as lectotype, has a height of 43.5 mm., with a maximum transverse diameter of 33.5 mm. The mouth of the shell is 23.5 mm. in maximum height and 17.5 mm. in maximum width. The protoconch is very characteristic. It is much more produced than that of the allied forms discussed here. The first $2\frac{1}{2}$ whorls, indeed, form a very distinct little conical projection. It has not the roughened surface of the protoconch of *L. malleata* nor the apical concavity of that of *L. lecythis*.

Shells from Erh-hai and from a swampy lake north of Ho-ching are much larger than the lectotype, from Chusan but otherwise similar. They exhibit considerable individual variability, however, and some approach Heude's *P. longispira*, which may perhaps be regarded as a distinct form, others his *P. ventricosa*, while the majority are nearest his *P. fluminalis*.

From the true *L. chinensis* they evidently differ in their acuminate apex, much thinner substance, paler colour and less oblique and more expanded mouth. These features also distinguish them from the forms *catayensis* and *ussurunsis* (of both of which I have good series before me) and they have not the angulate body-whorl of the larger Japanese forms.

Lectotype, 2332. *Ind. Mus.*

***Lecythoconcha malleata* (Reeve).**

(Plate 17, Fig. 9.)

1864. *Paludina malleata*, Reeve, *Paludina, Conch. Icon.* XIV, Plate V, Fig. 25.

1909. *Vivipara malleata*, Kobelt, *Paludina, Conch. Cab. (n.f.)*, p. 104, Plate XVII, Figs. 8-13 (not Plate XV, Figs. 8, 9).

This is a much more constant species than the other two discussed here and its wide geographical range exhibits little variation except in sculpture. Its range extends from the upper Yangtse to Japan. I have examined large series from both countries.

The shell is always comparatively small and broad in proportion to its height. Its sculpture and the form of its protoconch are characteristic. The latter, which is often remarkably complete, even in old shells, in Yunnan, is very prominent and consists approximately of a whorl and a half but merges gradually into the younger parts of the embryonic shell. The apex is minutely concave and the tip of the apical half-whorl blunt and distinct. Even the protoconch is minutely roughened though somewhat shining, and the remainder of the shell is ornamented with a reticulate sculpture consisting of numerous fine vertical and spiral striae. This is most conspicuous on the 2nd, 3rd and 4th complete whorls of the spire. It becomes somewhat obscure on the basal whorl (5th) of the spire and still more so on the body-whorl. On the last, however, there is always a series of fine, linear, spiral ridges which under the microscope have an irregular, often almost moniliform appearance. In some specimens there is a linear peripheral keel on the body-whorl. There are also as a rule a number of coarser varices on this whorl and similar varices sometimes occur on the whorls of the spire. They have a blackish colour. In dry shells the general colour is deep brown, with a purplish tinge on the apical whorls, but the fresh shell is green.

In specimens from Yunnan the sculpture is better developed than in most Japanese shells, but I have seen some from the province of Omi in which it is almost as prominent as in many from Yunnan. The highly sculptured Chinese form may be known as *f. occidentalis*, nov.¹

¹ Type-specimen. M ¹²⁴³⁶₂, Z.S.I. (*Ind. Mus.*).

All the specimens taken by the Gregory expedition are from the upper Yangtse system and I have no evidence for the occurrence of the species further west. Precise localities are Ho-ching (7,800 feet) and Shihku (6,200 feet). In Japan the species occurs at low levels and is common round Lake Biwa, but not in the lake itself so much as in rice-fields, etc. Most of the Yunnan specimens are from a swampy lake.

Family LIMNAEIDAE.

Genus *Limnaea* (auct.).

The Chinese species of this genus need revision and there can be no doubt that far too many have been described. This, indeed, is so in all countries. Fortunately I have the type-specimens of the two Yunnan species before me. One of these species occurs also in Indian territory and has been very fully considered by my assistant Mr. Srinivasa Rao and myself in an account of the Indian Limnaeidae we hope to publish shortly. This is *L. andersoniana* Nevill, the other is *L. yunnanensis* of the same author; they were both described from the late Dr. John Anderson's collection made in the west of Yunnan. A form of *L. yunnanensis*, for which a new name has to be found, was described later from Erh-hai by Neumayr under the inappropriate and incorrect name *L. auricularia* var. *yunnanensis*. He was evidently unaware of its relationship to *L. yunnanensis* Nevill, if he knew of the description of that form. I propose the new name *L. yunnanensis* f. *distensa* for this form.

Limnaea andersoniana Nevill.

1921. *Limnaea andersoniana*, Annandale and Prashad, *Rec. Ind. Mus.*, XXII, p. 574, Plate VIII, Figs. 1-6.

Further investigations extend the range of *L. andersoniana* on the North-West Frontier of India, in the Western Himalayas and in Turkestan. We find, indeed, that nearly all the Indian specimens hitherto referred to *L. truncatula* really belong to this species, though the true *L. truncatula* occurs at high altitudes in Chitral. The two species are related in an interesting manner but may be distinguished by the much shorter spire in all forms of *L. andersoniana*.

Specimens were taken at Yung-Chang (5,500 feet) on a tributary of the Upper Salween. They all belong to the typical phase of the species.

Type-specimen. M $\frac{12426}{2}$, Z S I. (*Ind. Mus.*).

Limnaea yunnanensis Nevill.

1877. *Limnaea yunnanensis*, Nevill, *Journ. Asiat. Soc. Bengal*, XLVI (2), p. 27.

1881. *Limnaea yunnanensis*, *id. ibid.*, L. (2), p. 142, Plate V, Fig. 8.

The species is closely related to the Indian *L. acuminata*, some of the smaller forms of which resemble it very closely. A constant difference is to be found in the outline of the lip of

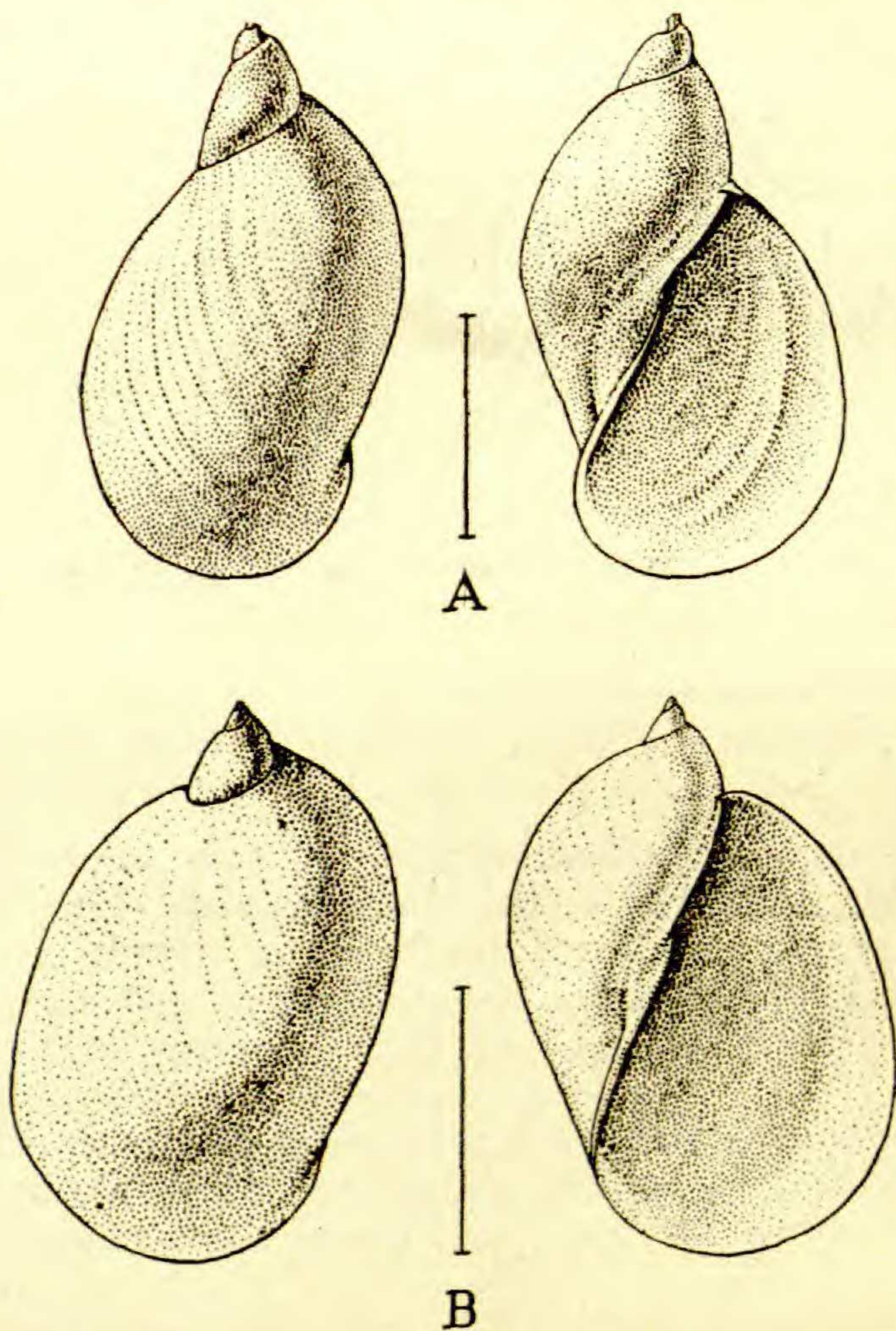


Fig. 1. *Limnaea yunnanensis* Nevill.

(a) Type-specimen of the species.

(b) Type-specimen of the form *distensa* from Erh-hai.

the shell, which in *L. acuminata* is never strongly arched in its upper half as it is in *L. yunnanensis*. My *L. shanensis* is also closely related, but its columellar callus is much better developed. The type-specimen of *L. yunnanensis* is 17.5 mm. high and Nevill evidently made some mistake in his description on this point.

Mr. Srinivasa Rao has extracted the radula and jaw from the type-specimen from Sanda. The latter forms a sector of a circle slightly less than a semi-circle and with a slight triangular projection in the middle of the posterior, otherwise straight margin. the side-pieces are slender, pointed below and of moderate length. The radula has the approximate formula 16.10.1.10.16. The central is relatively large and has a

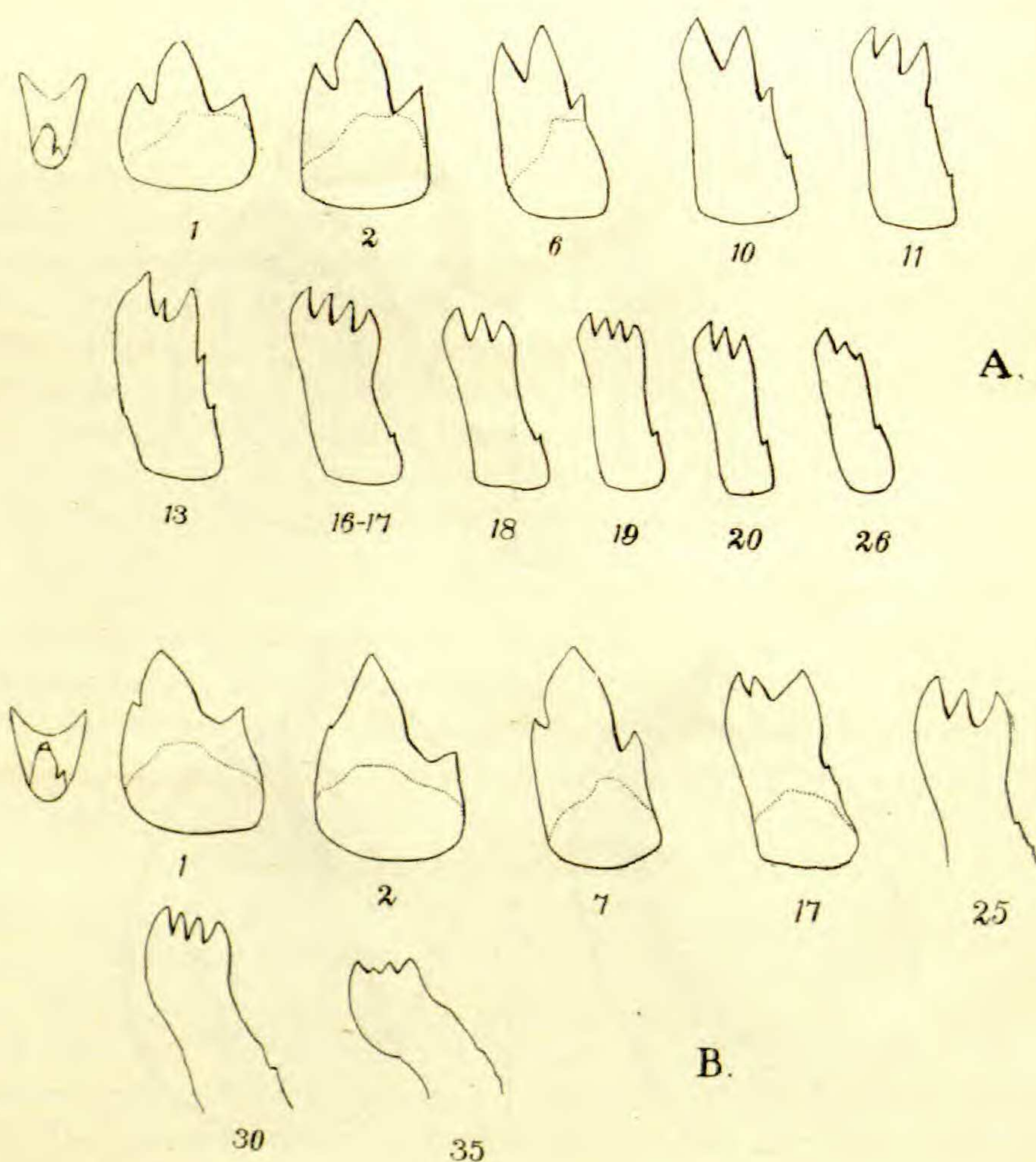


Fig. 2. Radulae of *Limnaea yunnanensis*.

- (a) From type-specimen of the species.
 (b) From a typical shell of the form *distensa*.

markedly asymmetrical bilobed cusp. All the laterals are tricuspid, with the entocone well developed. The first lateral on either side is relatively short and broad. The cusps of the marginals are horizontal and subequal. The most characteristic feature is the shortness of the first lateral, in which this species differ from both *L. acuminata* and *L. shanensis*.

Type-specimen. M $\frac{12+32}{2}$, Z.S I. (Ind. Mus.).

Form *distensa*, nom. nov.

1898. *Limnaeus auricularis* var. *Jünnanensis*, Neumayr in Bela Szécheny's *Reise in Ostasien*, II, p. 657, Plate XIV, Fig. 6.

This form is not really related to *L. auricularia*,¹ from which the shell differs in the structure of the columellar fold. In *L. auricularia* the outline of this fold, broad above and very narrow below, is extremely characteristic. In my new form it is uniformly narrow. The radula, moreover, and the genitalia are quite different. In particular the prostate is of

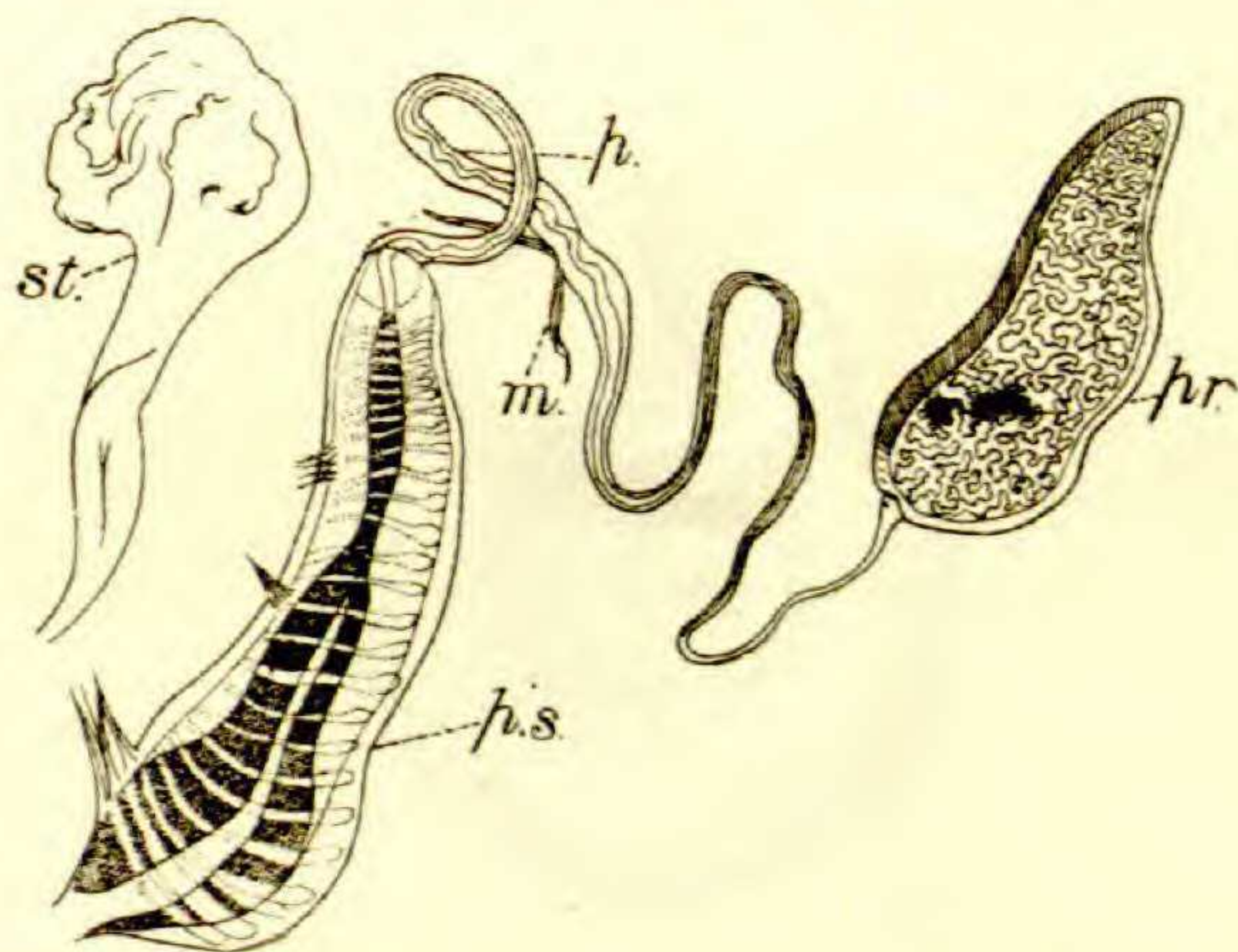


Fig. 3. Genitalia of *Limnaea yunnanensis* and *distensa*.

m., retractor muscle of penis; *p.*, penis; *pr.*, prostate; *p.s.*, penis-sack; *st.*, spermatheca.

a different shape and the spermatheca has a shorter duct. I figure the male part of the genital system and the spermatheca from a sketch by Mr. Srinivasa Rao. The radula in a specimen from the upper Salween system only differs from that of the type specimen of *L. yunnanensis* in that the entocone of the laterals is not so well developed.

Specimens of this form, with others intermediate between it and the *forma typica*, were taken both at Yung-Chang on the upper Salween and in a raised beach near the north-west shore of Erh-hai.

Type-specimen. M $\frac{12433}{2}$, Z.S.I. (*Ind. Mus.*)

Family PLANORBIDAE.

Gyraulus longios, sp. nov.

1878. ? *Planorbis compressus*, Nevill in Anderson's *Zool. Anat. Res. Yunnan*, p. 388.

The shell is of a moderate size, very flat, with both surfaces broadly and shallowly concave, with a distinct, deep umbili-

¹ The two forms, indeed, belong to different sections of the genus *L. auricularia* to *Radix* Montfort and *L. yunnanensis* to *Pseudosuccinea* Baker.

cus in the centre of the lower surface, with $3\frac{1}{2}$ whorls. The periphery of the body-whorl is subcarinate and there is a distinct angle or low carina on the outer part of the whorl above. The suture is broadly impressed, oblique and irregular. The mouth is very broad and shallow, narrowly oval, strongly depressed and oblique, extending far below and beyond the remainder of the shell, with the peristome complete and angulate internally, but without a strongly developed callus. The outer lip is convex and sharp, without any internal thickening. The sculpture consists of moderately well developed, fairly

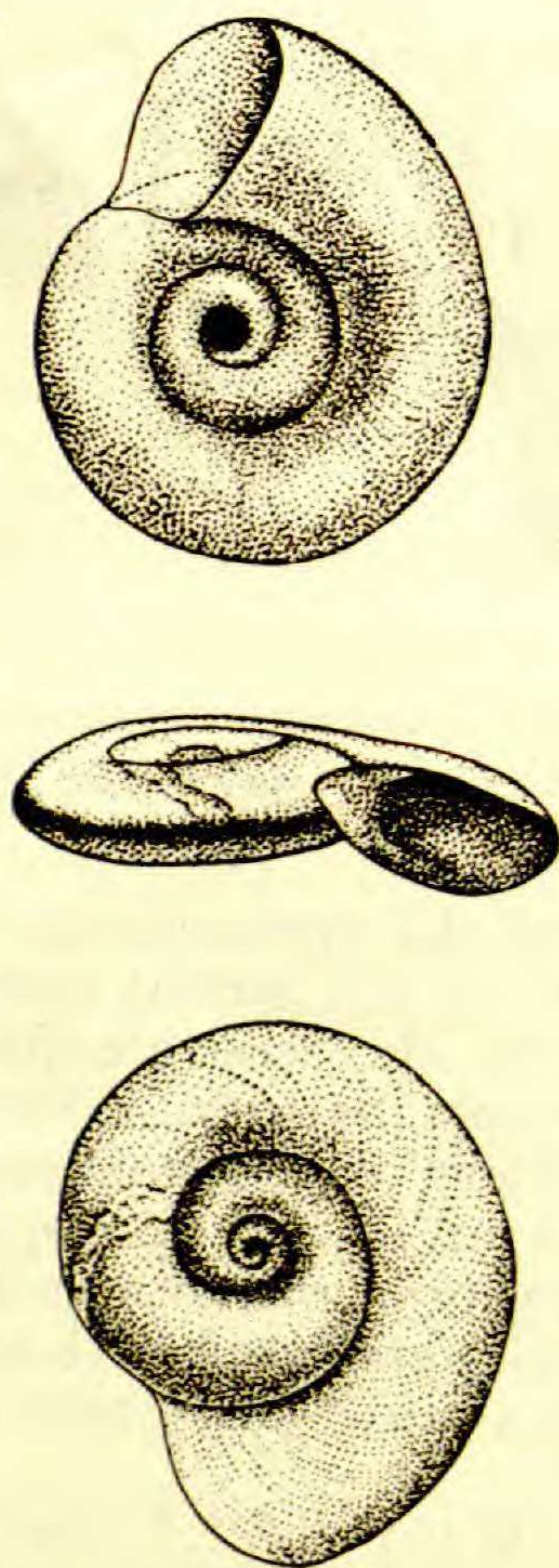


Fig. 4. Type-specimen of *Gyraulus longios*, sp. nov.

regular vertical striae and numerous extremely minute spiral striae. The colour is pale horny, but there is a thin greyish deposit on the shell examined. Max. diam., 4.5 mm.; min. diam., 4.2 mm.; height, 1.5 mm.

Locality. Cliff above the Awa bend of the Upper Mekong. Altitude, 6,400 feet.

Type-specimen. No. M. $\frac{12407}{2}$ Z.S I. (*Ind. Mus.*).

The specimens from Sanda doubtfully referred by Nevill to *G. compressus* Hutton (= *euphraticus* Mousson) probably

belong to this species; Dr. Germain has referred them to *G. saigonensis*. I have not examined them as they are still with Dr. Germain. I regard my species as distinct from *G. euphraticus*, because the shell is still flatter, distinctly umbilicate, less strongly keeled and with the mouth still broader and more oblique. The minute sculpture also seems to be different and the angulation of the body-whorl above peculiar.

DESCRIPTION OF PLATE 17.

CHINESE VIVIPARIDAE.

The vertical line between the two views of each shell represents its actual height.

Vivipara angularis (Müller).

Fig. 1. Typical shell from Canton.

V. quadrata (Benson).

Fig. 2. Typical shell from Canton.

V. quadrata f. *dispiralis* (Heude).

Fig. 3. Denuded shell from raised beach, Erh-hai, Yunnan.

V. quadrata f. *limnophila*, Mabilie.

Fig. 4. Partly denuded shell from the same locality.

V. quadrata f. *minor* (Nevill).

Fig. 5. Large shell from Western Yunnan.

V. margaryoides Annandale.

Fig. 6. Type-specimen from raised beach, Erh-hai, Yunnan.

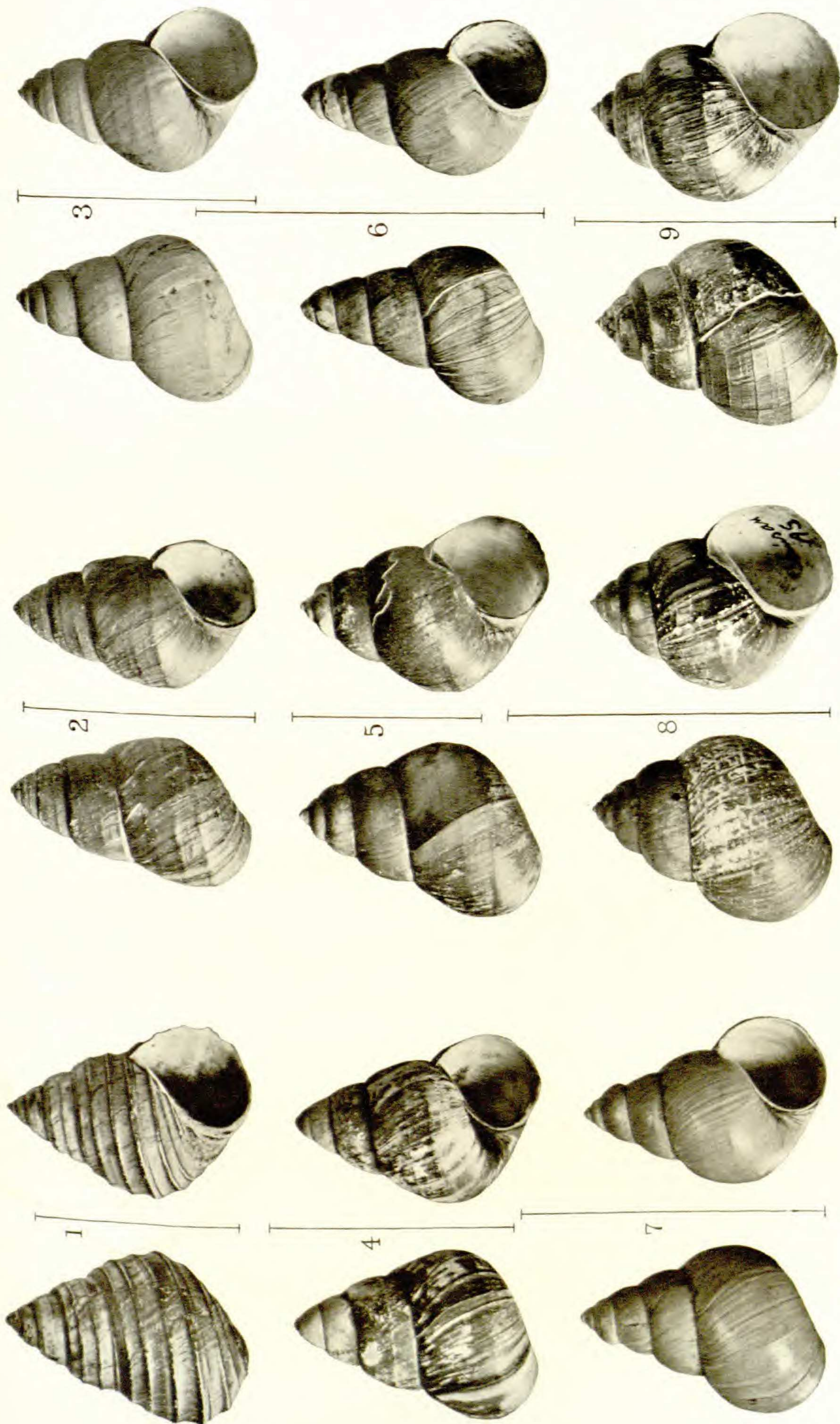
Fig. 7. Another shell from the same series.

Lecythoconcha lecythoides (Benson).

Fig. 8. Lectotype from Chusan.

L. malleata f. *occidentalis*, nov.

Fig. 9. Type specimen from Ho-Ching, W. Yunnan.



S.C.Mondul phto

CHINESE VIVIPARIDAE.